MINERAL AND ORGANIC ANALYSES OF FOODS

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MINERAL AND ORGANIC ANALYSES OF FOODS

NEW METHODS FOR THE DETERMINATION OF SODIUM AND CRUDE FIBER

By E. B. FORBES, F. M. BEEGLE AND J. E. MENSCHING

In the course of the investigations of this laboratory there have been accumulated a considerable number of food analyses, which, it is thought, may be of sufficient interest to students of nutrition to warrant their publication. These analyses cover an extensive range of substances including representatives of all the groups of food products, and comprise determinations of both organic and inorganic constituents. The tables include also computations of the balance of acid to basic elements in foods, as made by Sherman and Sinclair*, which call attention in a useful way to an important detail in their character.

Few of our American agriculturists have given attention to the mineral elements in foods, and most of those who have made ash analyses have been students of soil fertility rather than animal nutrition, and so have prepared their samples for analysis in such a way as to indicate the draft upon the soil rather than the value of the products as animal foods. In our analyses, only such parts of the natural products are represented as are edible by the kind of animal usually consuming them.

These analyses do not include determinations of iron. While this is a matter of some importance, as related to human nutrition, the contamination of the samples with iron in the usual methods of preparation probably exceeds the amount properly present, and the special preparation necessary for accurate iron estimations was not practicable under the conditions attending this work.

*Sherman and Sinclair: Jour. Biol. Chem., Vol. 4, No. 2, 1909.

Most of the inorganic analyses of foods in our text and reference books are both ancient and foreign. Considerable progress has been made in recent years in analytical methods, and the ash content of foods is much influenced by soil and climate. It is thought, therefore, that recent analyses, by approved methods, of American-grown products have a value to American students which is not possessed by the older work of European agriculturists.

It is not our purpose to present anything like a complete series of food analyses, nor a general discussion of nutrition, but in view of the amount of labor involved in such determinations, simply to record those which we have so that they may be of use, and also to point out some of the more important truths which they exemplify.

The usual organic food analyses are not discussed in this article, although these determinations are included in the tables on pages 225 to 231, and are here recorded for reference in connection with the mineral analyses.

CHEMICAL METHODS

The chemical methods followed in this work are as indicated below:

Ash: On vegetable substances, the hydrochloric acid leaching method, (see Ohio Bul. 222, p. 44); on animal products by the official water-leaching method.

Moisture: Vacuum method, over sulphuric acid.

Nitrogen: Gunning method.

Fat: Ether extract.

Crude Fiber: Original method; see below.

Sodium: Original method; see below.

Potassium: Lindo-Gladding method.

Calcium and magnesium: McCrudden method.

Sulphur: Provisional peroxide method of the A. O. A. C.

Chlorine: Provisional method of the A. O. A. C. for plant substances.

Phosphorus: Official gravimetric method. With vegetable substances this determination was made on a hydrochloric acid solution of the ash; with animal products, except egg, it was made in the same way; with egg the oxidation was accomplished by the nitric-sulphuric acid digestion method.

Inorganic phosphorus: Methods of this laboratory published in Ohio Bul. 215.

CRUDE FIBER METHOD

The crude fiber method used in this work is an improvement on the Morgan P. Sweeney modification of the official method, the improvements consisting in filtration through asbestos and sand

in a Gooch crucible, treatment with hydrochloric acid, washing without transfer, and ignition in the Gooch crucible. The details are as follows:

To a 1 or 2 gram sample add 200 c. c. of boiling 1.25 percent sulphuric acid, and boil for 30 minutes.

Neutralize with 10 percent sodium hydrate using phenolphthalein as an indicator; add 200 c. c. of 2.656 percent boiling sodium hydrate; make volume up to 425 c. c. and boil for 30 minutes.

Filter through a porcelain Gooch crucible containing an asbestos pad and 10-12 grams (½ inch) of very fine acid-washed sand,* compacted by water and suction. Treat with 1.25 percent hydrochloric acid, wash with hot water until free from chlorides, and then with alcohol and ether; dry, weigh, ignite and weigh. The difference in weights represents crude fiber.

The improved method sometimes gives higher figures than the official method. In general the results check, one with another, very satisfactorily, and the method is much easier to use.

The unsatisfactory character of the official method is too well known to require comment. This new procedure eliminates all transfer of the sample, and also the unstandardized cloth strainer, for which it substitutes a filter which is thoroughly efficient, and which at the same time allows of very rapid filtration of solutions, such as those from linseed and cottonseed meals, which are very difficult of filtration by any other method. The use of hydrochloric acid facilitates the final washing A microscopical examination of the crude fiber and the filtrates from the official, and from our modified methods showed that the higher results obtained by the latter were due to undissolved, woody and chitinous particles which passed through the linen but which were retained by the sand and asbestos. In the products examined there was no evidence of contamination of the crude fiber as determined by the improved method by gummy or protein substances.

Objection to the Sweeney method has been raised on account of difficulty with the colored extracts of some feeds in determining the neutral point. This objection is not insuperable in any case, and in using this method with the wide range and considerable number of products included in this discussion we found that it was in rare instances only that the color of the extract interfered with the use of the indicator.

The slow filtration by the Sweeney method is entirely overcome in our modification.

*Sand satisfactory for this purpose has been purchased from the Berkshire Glass Sand Co. of Cheshire, Mass. Coarse sand was found not to be useful, the reason being that it allows the fiber to pass through and then to clog the asbestos pad Do not use more sand than experience shows to be necessary, on account of the difficulty of washing it free from chlorides.

Objection has also been raised to the Sweeney method on account of possible interference of the fat with the solution of the acid– and alkali–soluble constituents. This possibility, however, has not been proven appreciably to affect results.

Whatever the method under consideration, we are unable to judge of its accuracy by comparison with the official method, because of the lack of definiteness as to the character of the cloth strainer, and because of the incomplete retention of the crude fiber of some products by such a filter.

Below are a few determinations made by our improved method, in comparison with results from the official procedure. The sample in each case weighed one gram. The figures are weights in grams of crude fiber.

	Official method	Modified method
Cowpeas	.0544 .0560 .0570	.0568 .0564 .0554
Linseed oil meal	.0922 .0908 .0910	.1110 .1118 .1112
Corn meal	.0228 .0212 .0238	.0272 .0280 .0272
Soybeans	.0470 .0472	.0482 .0484
Distiller's grains (corn)	.1232 .1228	.1239 .1240
Oats, grain	.1215 .1212	.1217 .1215
Wheat bran	.0837 .0830	.0856 .0868
Wheat, grain	.0324 .0331	.0332 .0332
Patent flour	.0010 .0012	.0025 .0025
Gluten feed	.0892 .0891	.0886 .0881
Cottonseed meal	.0705 .0703	.0710 .0720

SODIUM METHOD

The reason for attempting an improvement on the official method for the estimation of sodium is that by this method it is very difficult entirely to free the combined sodium and potassium sulphates from phosphates. To get duplicate results which check is not so difficult; but a test for phosphorus is very apt to demonstrate the impurity of the salts. We do not affirm that it is impossible to free the sulphates from phosphates by the official method, but the amount of manipulation often necessary for the attainment of this

result is apt to leave one without faith in the determination. The new method gives better checks, requires less manipulation, and the sulphates are not contaminated by phosphates. The procedure is as follows:

METHODS OF PREPARING SOLUTION

(a) Digest sample with nitric and sulphuric acids in a Kjeldahl flask as for a phosphorus estimation;* make the solution up to volume; take for the determination such aliquots as will represent 2-4 grams each of the fresh substance, and neutralize with ammonia; or (optional):

(b) Moisten the sample with dilute sulphuric acid, and burn at a temperature below red heat. Digest the ash in dilute hydrochloric acid and filter; bring the filter paper and residue to dryness in a platinum dish; ignite; digest in hot water; filter, and add the filtrate to the one resulting from the first ignition; make the solution up to volume, and take for the determination such aliquots as will represent 2-4 grams each of the fresh substance.

DETERMINATION

Precipitate out the phosphorus with magnesia mixture and 10 cc. of ammonia. Allow to stand over night, and filter into a beaker.

Evaporate the filtrate to a low volume, transfer to a platinum dish, bring to dryness, and continue heating on a sand bath until ammonia fumes are evolved; then burn off all ammonium salts over a flame.

Take up the residue in the platinum dish with hot water; transfer to a beaker, and heat; then add enough freshly prepared barium hydrate solution completely to precipitate the magnesium. Let the precipitate settle for a few minutes, and test for complete precipitation. When no further precipitation is produced, filter, and wash thoroughly with hot water.

Heat the filtrate to boiling; make alkaline with ammonia, and add ammonium carbonate to precipitate the barium, calcium, etc.

Filter into a beaker; add a drop or two of hydrochloric acid and 1 c. c. of ammonium sulphate solution, (75 gr. per liter), and digest for several hours on a steam bath.

Transfer into a platinum dish, evaporate to dryness and ignite; dissolve in hot water and filter into a weighed platinum dish, in which evaporate, ignite, heat to constant weight, and weigh as sodium and potassium sulphates.

Note—All ammonium salts must be driven off after precipitation of the phosphorus with magnesia mixture. The barium hydrate solution must be freshly prepared.

*The sulphuric and nitric acid digestion seems not to introduce a perceptible error through the solution of the Jena glass flask in which this process is conducted.

Below are a few estimations made by the official and by the new methods. The figures represent grams of sodium and potassium sulphates from 1 gram of substance.

	Official method*	New method
Distiller's grains	.0039 .0049	.0034 .0035
Snake weed...	.0227 .0333	.0180 .0180
Cottonseed meal	.0529 .0563	.0479 .0484
Brewer's grains	.0151 .0239	.0132 .0124

Some determinations by the new method alone are as follows:

Apple ..... .0194 .0203	Milk..... .0448 .0411	Peanuts ..... .0185 .0189
Banana..... .0194 .0184	Eggs ..... .0165 .0165	Rice..... .0018 .0018
Sweet potato. .0384 .0390	Alfalfa hay.. .0334 .0339	Tankage..... .0705 .0692
Navy beans.. .0334 .0333		

DISCUSSION OF MINERAL ANALYSES

Perhaps a useful suggestion to the student of these tables is that the inorganic products vary remarkably in accord with the conditions of growth, especially as relating to soil, rainfall and sunshine, and also rapidity of growth and stage of maturity attained. The variation in organic constituents, however, is very much less than in mineral elements. This variability is much more prominent in roughage and roots than in cereals and fruits. The general character only of the ash analysis of a vegetable product remains characteristic.

In the interpretation of these analyses we may keep in mind certain observations as follows:

(1) In general, a high ash content of the food is desirable, since the animal is better able to cope with an excess of ash constituents than with a deficiency.

(2) The greatest deficiency in the mineral nutrients of common foods is in calcium (lime).

(3) Phosphorus is also often deficient.

(4) The other mineral elements are not likely to be deficient in common foods, except for sodium and chlorine, which are usually added in superabundant measure as common salt.

(5) Magnesium contributes more than other mineral elements to the laxative character of foods.

*The weights of sulphates by the official method fail to check by reason of contamination with phosphates. Test showed no phosphates present in sulphates obtained by the new method.

(6) Foods which are high in ash constituents generally are apt to be laxative, while those which are low in ash are often constipating.

(7) An excess of basic mineral elements over acid mineral elements in the food is desirable. The body is able to compensate for a certain excess of acid, but this capacity is limited. Too close an approach to this limit is a disadvantage to the animal, and restricts the growth of bone; if it is exceeded death ensues.

(8) Sodium and chlorine are always available in the form of salt. Potassium and magnesium are probably always present in sufficient quantity in practical rations. Sulphur is present in foods almost entirely in their protein compounds, and hence varies with the protein, and is not lacking if the ration is properly balanced in regard to nitrogenous and non-nitrogenous nutrients. Calcium and phosphorus alone are frequently lacking in otherwise well balanced rations, though iron is also occasionally deficient.

(9) Those animals with which the mineral nutrients are most important are young, growing animals, and pregnant, milk-giving or egg-laying females. The mature work animal needs comparatively little mineral matter.

WHEAT PRODUCTS

Considering the cereals as essential components of practical rations of both man and his animals, let us examine the ash analyses of cereal products, and also those of other foods which may be used with the cereals. (Table I., p. 225.)

Among the various products of the wheat grain our greatest interest is in the white flour. It contains less mineral matter than any other wheat product, and therefore requires that the mineral necessities for growth be very largely provided by other articles in the dietary. Not only is the total ash low but the individual elements are each one present in very small quantities, and hence we must regard white flour as a poor food for all purposes served by mineral matter. In every-day life the one deficiency of white flour which is most likely to make itself apparent is its lack of magnesium, this deficiency causing its constipating character, a matter of no concern to most healthy adults, but one of much importance in the feeding of the very young and others who for any reason must subsist on a diet of limited variety. Actual disease is probably not often caused by the lack of mineral matter in white flour, though there is reason to believe that beriberi, as found in certain communities of poor fishing-folk in Labrador, may be caused by the mineral deficiencies of the diet, which consists during the winter months largely of white bread and tea.* Whatever the exact cause of this malady it

*Little, J. M., Journ Am. Med. Assn., vol. 58, p. 229.

is readily curable by the use of the coarser parts of the wheat, as was first proven on a large scale when a ship-load of whole-wheat flour was wrecked on the Labrador coast at a point where beriberi was prevalent. Much disadvantage of a less acute degree may fairly be attributed to the mineral deficiencies of white flour. Among the many methods available for getting the minerals of the wheat into the dietary, as wholesome as any, and the cheapest, is the use of graham bread.

Next after wheat flour wheat bran is the best known wheat product. It contains about 3.5 times as much ash as does wheat, and on this account is popularly supposed to be a good bone food. This, however, is an erroneous impression. Bran by itself is a very poor bone food, so poor that an excessive use of bran causes a well known bone disease, "miller's horse rickets," "bran disease" or "shorts disease." The characteristic of bran which makes it a poor bone food is its low calcium content. Bran is very rich in magnesium, to which fact is due in part its well known laxative tendency.

The high phosphorus content of bran is its greatest mineral asset, though it is not possible for the animal to make use of this phosphorus unless other foods in the ration supply the calcium with which most of the phosphorus must be united in its use by the animal.

The mineral bases which are present in bran in such large amounts contribute but little to its value as a foodstuff, since the predominating ones, magnesium and potassium, are not used by the animal in large quantities, and are those which are almost invariably present in excess in ordinary rations.

Wheat middlings possess the same general character as wheat bran, as regards mineral content, though the amount present of each constituent is somewhat less; but the same lack of balance between the elements prevails, as is attested by the fact that a pig will not thrive long on middlings alone, nor for many months on corn and wheat middlings, if no other food be allowed. To get the best use of middlings or bran, or indeed, of any other cereal food, it must be used with other foodstuffs containing much more calcium.

The lowest grade of wheat flour, known as "red dog," and which is used for feeding purposes, has a mineral composition much like that of wheat middlings, but contains very much less potassium Potassium and crude fiber vary in a general way together, in these wheat products, and indeed in many other foods.

Wheat germs are used by large manufacturers in the preparation of human foods. The small miller, however, puts them into the middlings. Though obtainable they are not on the general market

unmixed with other parts of the wheat. Chemically they are of interest because of their high content of nuclein phosphorus, but no especial advantage has been found to depend upon the fact that the phosphorus is present in this particular condition.

Wheat gluten is prepared as a flour for diabetics. The most marked peculiarity of its ash analysis is its high sulphur content, this being due to its being almost a pure protein, the sulphur being present almost wholly as a constituent of the nitrogenous compounds.

In common with other cereals the wheat preparations have almost equivalent amounts of acid and basic mineral elements, but usually with a slight preponderance in favor of the acids. A considerable excess of base in the remainder of the ration would therefore be desirable. In common with other cereals the wheat products also have their phosphorus present almost entirely in organic forms.

The wheats represented by the mineral analyses in Table IV, p. 228, are from the 1911 crop of the 5-year rotation series of the Soils Department of this Station. As was demonstrated by the extensive work of J. W. Ames, published in Bulletin 221 of this Station, there are marked variations of the composition of the wheat grain in accord with the fertilizers applied, but when we consider these variations as indications of food value we find that their magnitude is not such as to render them practically important. In actual practice variations in the calcium and phosphorus of rations are alone likely to be of importance. The range of variation of calcium in these wheats is .013 of one percent, and the variations in phosphorus cover a range of .069 of one percent. Now, when we consider the small proportions of these amounts of calcium and phosphorus in wheat which are present in wheat flour, we appreciate the fact that these variations are not important in connection with human nutrition, though the differences in mineral nutriment in the *different* human foods are matters of importance, and should enter into the determination of our choice from among those available; and it is also true, as we have shown in Ohio Bulletin 222, that the roughages fed to animals vary in accord with the fertility of the soil to such extent as is practically important.

CORN PRODUCTS

Corn (maize) contains less ash than wheat (Table I, p. 225); less ash than any of our cereals except Kaffir corn and related species, and is in general the poorest bone food available to the stock feeder. Its

economical utilization by growing or breeding animals, or animals producing milk or eggs, requires that foods used with corn should contain decidedly more calcium than corn contains. The deficiency of corn in calcium is much greater than in protein.

Bolted corn meal, as prepared for human consumption, lacks the skin and a portion of the germ of the kernel. The exclusion of these portions of the grain still further lowers the value of the product to a growing animal. The germ is removed from corn in the manufacture of meal for human consumption in order to increase its keeping quality. Corn meal containing the germs becomes musty much more quickly than meal from which they have been excluded.

Corn bran is not generally on the market. Those business interests which control the manufacture of corn products in this country find that the most profitable way to dispose of the corn bran is to grind it fine, and then to mix it with products of greater food and market value; corn germ meal and gluten meal in the pure state have, therefore, been generally withdrawn from the market, and are usually obtainable only mixed with corn bran, and are then known as hominy feed and gluten feed. Corn bran, because of its indigestible character, has a low feeding value.

Pearl hominy contains less mineral nutriment than any other of the corn products, since in its manufacture the skin and germ are removed more completely than in the manufacture of bolted corn meal.

Distiller's grains from corn also contain but little mineral nutriment.

Gluten feed contains more mineral nutriment than other corn products, though not so much as the other nitrogenous concentrates, linseed and cottonseed meals. The difference in the mineral nutrients of these concentrates should enter more largely into the determination of the market price than it does, considering them both as animal foods and as sources of soil fertility.

OTHER CEREAL PRODUCTS

Distiller's grains from rye and brewer's grains and malt sprouts from barley, contain somewhat more mineral nutriment than does corn, but are not notable in this regard. The same may be said of oats. The high ash content of oats is due largely to the silica in the hull.

Polished rice contains less mineral nutriment even than any corn product, and too large a use of polished rice is the usual cause of beriberi. The use of unpolished rice prevents and cures this disease.

Rice polish is exceedingly rich in potassium, magnesium and phosphorus. The general character of the ash analysis is much as in wheat bran. In common with all the cereal foods it is very low in calcium.

Considering these cereals and cereal products as a group, we observe that from the point of view of this discussion the dominant characteristic which they have in common is the lack of lime. The acid mineral elements slightly and rather uniformly exceed the basic elements, and the phosphorus is almost wholly organic. Wheat bran, wheat middlings, red dog flour, and rice polish are remarkable because of high phosphorus contents, which would be an advantage in rations containing the calcium necessary to the utilization of the phosphorus.

Considering the cereal products as human foods, the greater acceptability of the highly milled products is attained at a considerable loss of mineral nutriment, and the use of these modern products requires more careful consideration of the remainder of the diet than was necessary in the days of primitive milling processes.

Growing animals subsisting on cereals alone soon come to suffer from malnutrition of the bones.

Since the economical utilization of the cereals as foodstuffs is one of the most important of our problems, we now logically turn to those foods which are, by nature, adapted to supplement them.

LEGUMINOUS AND OTHER ROUGHAGE

The leguminous roughages, clover, soy bean, cowpea and alfalfa hays, taken as a group (Table II p. 226), in addition to a general similarityof mineral contents, are alike in the possession of a very high calcium content and a marked preponderance of basic over acid mineral constituents. Where the cereals are weakest, the leguminous roughages are strongest. Among the many reasons why we should raise legumes one of the most important is this natural fitness which they possess to make good the greatest mineral deficiency of our most highly valued field products, the cereals. In a general way this combination of cereal products and leguminous roughage makes a perfect ration. Other improvements are of a minor order.

Roughages are so variable in composition that it is not wise to attempt to compare one of these legumes with another on the basis of single analyses.

The cereal roughages, timothy and millet hay, blue grass, corn stover and wheat straw, are likewise characterized by an excess of basic over acid minerals, and are also richer in calcium than are the

seeds of the same plants. Both these desirable characteristics are possessed by these foodstuffs in much smaller measure than by the leguminous roughages, and they have, consequently, a lower value as supplements to the cereal grains for feeding purposes.

The phosphorus of roughages, both leguminous and cereal, is much more nearly equally divided between organic and inorganic compounds than in the grains, doubtless due to the greater transpiration of water by the leaves of plants than by the seeds, and thus to the consequent incidental residue of phosphates within their tissues.

LEGUMINOUS SEEDS AND CONCENTRATES

Leguminous seeds such as soybeans, navy beans, cowpeas, peanuts, etc., (Table III, p. 227) have very high feeding values; the range of their usefulness is wide, and is being rapidly extended. On the mineral side they are qualified to some extent to supplement the cereals, because of an excess of basic over acid mineral elements, and greater contents of calcium, but they possess both of these qualities in smaller measure than the roughages of the same species. Because of their high protein contents, and their limited capacities to make good the deficiencies of the cereals, their place in the dietary is often likened to that of meat.

Linseed and cottonseed meals are richer in calcium, magnesium and phosphorus than the leguminous concentrates. They do not differ from them widely in balance of acid to basic mineral elements. Their great usefulness in the rations of farm animals is due partially to their high mineral contents, and the elements of fertility contained in their residues have a value equal to a considerable part of the cost of the food. They are superior to gluten feed in all the ways in which the minerals affect the value of these products.

ANIMAL PRODUCTS

Among the animal products (Table III, p. 227) milk merits especial attention since it may fairly be considered a perfect animal food. It is characterized by an excess of basic over acid mineral elements, and contains considerably more calcium than phosphorus, and generous amounts of both of these, on the dry matter basis. Its phosphorus is a little more largely in inorganic than in organic compounds.

Whey contains a greater proportion of basic to acid mineral elements than does milk, since the curd removes more acid than basic mineral elements from milk. The ready assimilability of its organic constituents, and the corrective tendency of its minerals in the various digestive disturbances of infancy, especially those in which acidosis is a feature, make whey the rational basis for the modification of milk for infants. Perhaps no single bearing of this

matter of the mineral elements in nutrition is likely to cut more of a figure in the happiness of the average man than the use of whey rather than water in the modification of milk. Whey is also especially useful in severe illness of older children. Many a child has been taken through protracted sieges of fever on whey alone.

Its mineral salts correct the tendency to acidosis in such diseases, and the milk-sugar and albumen contained are sufficient in amount to be of great value. It may be prepared fresh from skim milk by the use of the commercial rennet extracts obtainable at any drug store, or from the evaporated commercial product from which this analysis was made.

Meat, like the cereals, is extremely low in calcium, and like them, will cause malnutrition of the bones if used to the exclusion of other foods. Carnivorous animals naturally make good this deficiency by eating bones.

Tankage is a packing-house product consisting of a mixtue of meat and bone scrap, dried and ground. It is also apt to contain paunch contents, salt, sand, and other foreign matter. It is rich in all of the mineral nutrients, and makes a complete, and at least practically perfect supplement to the cereals for swine. Similar preparations serve the same purpose for poultry except that in addition poultry require a supply of calcium carbonate, which is most advantageously supplied as oyster shell.

"Banner bone flour" is a precipitated calcium phosphate prepared from bone, and consists of a mixture of the dicalcic and tricalcic phosphates, with the former predominating. It is a useful addition to a ration which lacks bone-forming constituents.

Finely ground bone has a certain advantage over the above-mentioned precipitated bone earths in its greater proportion of calcium to phosphorus, but is difficult to obtain in a sufficiently finely ground condition to be generally acceptable to live stock.

Blood preparations are useful as high-protein foodstuffs, but, like meat, are deficient in calcium.

Eggs also are low in calcium, a deficiency which the incubating chick makes good by withdrawing calcium carbonate from the shell. Eggs are rich in phosphorus, however, in organic compounds, mostly lecithin, which has a high nutritive value, and which is a universal cell constituent.

Considering the animal products as a group, they usually contain an abundance of phosphorus, but only milk and bone preparations contain enough calcium to make them of value on this account in supplementing the cereals.

FRUITS AND VEGETABLES

Fruits and vegetables (Table II, p. 226) have in common a very decided preponderance of basic over acid mineral nutrients, due largely to high potassium and low phosphorus contents, the bases being present as salts of organic acids which are oxidized in the body, the acid radicle being excreted as carbon dioxide and water, and the inorganic bases becoming free for the neutralization of mineral acids which cannot thus be oxidized to harmless products. This fits them admirably to serve as supplements to the cereals and leguminous seeds. They are, on the dry basis, moderately rich in calcium.

CONCLUSION

All things considered, then, the ration which is most likely to contain in abundance all of the mineral nutrients required by animals, is one characterized by diversity of origin, no one class of foods greatly exceeding others. A diet of cereals, or of meat, or eggs, or of any combination of these three, would not be well proportioned. Cereals and milk, or cereals and fruits, or cereals and vegetables, would make better proportioned dietaries.

Grouping together the foods with acid ash—cereals, meats and eggs, and opposing to them those of alkaline ash—fruits, vegetables, milk and legumes, the latter group should be liberally represented in the dietary.

Among single foods, milk and the legumes are perhaps more nearly complete foods on the mineral side than others, though there are many reasons why extreme simplicity of diet is not advantageous.

Those circumstances most likely to lead to error in this matter of the mineral elements in nutrition are poverty, parsimony, fads and indifference, in which connection we would repeat the expression of the old lady who prayed, "Oh Lord, make the indifferent different."

NOTE—Of the following tables, Nos. I, II and III are mineral analyses of foods stated on the dry basis. Tables V, VI and VII contain ordinary food analyses as well as mineral analyses and are stated on the fresh basis. These tables represent the same products as tables I, II and III, and the arrangement is the same. Table IV shows the effects of fertilizers on the wheat grain.

TABLE I—MINERAL ELEMENTS OF CEREAL PRODUCTS—PARTS PER 100 OF DRY SUBSTANCE.

	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus	Inorganic phosphorus	Organic phosphorus	C. C. Normal Solution per 100 Grams			
											Total base	Total acid	Excess base	Excess acid
Wheat	1.866	.590	.035	.056	.142	.224	.095	.425	.038	.387	31.10	44.11	....	13.01
Wheat flour	.192	.058	.127	.022	.019	.168	.081	.102	.017	.085	9.61	19.39	....	9.78
White bread	1.695	.156	.583	.038	.004	.198	.958	.135	.043	.092	31.46	48.10	....	16.64
Wheat bran	6.729	1.464	.223	.139	.590	.297	1.000	1.233	.034	1.199	102.42	100.88	1.54	.....
Wheat middlings	4.630	1.147	.186	.108	.430	.263	.029	.984	.069	.915	78.08	80.71	....	2 63
Wheat germ	5.147	.323	.788	.078	.372	.355	.077	1.147	....	....	76.81	98.31	....	21.50
Wheat gluten	.780	.007	.031	.085	.049	1.000	.055	.220	.037	.183	9.78	78.12	....	68.34
Red dog flour	4.151	.425	.733	.134	.324	.285	.156	.928	.098	.830	75.94	82.01	. ..	6.07
Corn	1.410	.396	.030	.014	.126	.171	.073	.303	.028	.275	22.43	32.31	...	9.88
Corn meal, bolted	.790	.192	.113	.015	.122	.122	.070	.264	.019	.245	20.56	26.62	....	6.06
Corn bran	1.330	.410	.000	.030	.088	.124	.052	156	.031	.125	19.19	19.27	...	0 06
Pearl hominy	.600	.153	.000	.005	.036	.182	.052	.111	.019	.092	7.11	19.98	....	2.87
Gluten feed	3.460	.272	.461	.268	.239	.636	.098	.589	.106	.483	59.94	80 42	....	20.48
Distiller's grains, corn	1.500	.014	.154	.047	.054	.509	.065	.314	.056	.258	13.75	53.87	....	40.12
Distiller's grains, rye	3.692	.045	.077	.142	.195	.408	.028	.458	.018	.440	27.58	55.80	....	28.22
Brewer's grains	2.953	.185	.278	.169	.172	.419	.062	.503	.162	.341	39.29	60.31	....	21.02
Malt sprouts	6.153	.219	1.458	.159	.194	.864	.389	.746	.471	.275	92.72	112.99	....	20.27
Oats	3.709	.460	.184	.112	.130	.214	.077	.434	.059	.375	35.95	43.49	....	7 54
Kaffir corn	1.339	.288	.066	.013	.142	.186	.117	.271	.012	.259	22.51	32.42	....	9.91
Rice	.315	.040	.032	.009	.028	.114	.040	.104	.003	.101	5.12	14.89	....	9.77
Rice polish	8.024	1.279	.124	.030	.741	.189	.151	1.684	028	1.656	100.38	124.72	....	24 34

TABLE II—MINERAL ELEMENTS OF FRUITS, VEGETABLES AND ROUGHAGE—PARTS PER 100 OF DRY SUBSTANCE.

	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus	Inorganic phosphorus	Organic phosphorus	C. C. Normal Solution per 100 Grams			
											Total base	Total acid	Excess base	Excess acid
Apple	1.807	.802	.066	.027	.033	.044	.037	.064	.033	.031	27.39	7.93	19.46	....
Prune	2.845	1.347	.045	.076	.056	.066	.050	.110	.098	.012	44.76	12.59	32.17	....
Banana	2.925	1.291	.240	.037	.129	.021	.421	.119	.089	.030	55.86	20.87	34.99	....
Date	1.920	.667	.115	.084	.086	.087	.285	.077	.037	.040	33.09	18.42	14.67	....
Onion	4.304	1.442	.097	.261	.136	.601	.183	.323	.210	.113	65.14	63.44	1 70	....
Cabbage	7.189	2.484	.028	.590	.209	.901	.243	.262	.136	.126	111.18	80.00	31.18	....
Potato, sweet	3.133	1.208	.061	.084	.215	.117	.069	.186	.138	.048	55.37	21 26	34.11	....
Potato, white	3.815	1.547	.175	.027	.331	.141	.055	.270	.130	.140	75.63	27.70	47.93	....
Mangel wurzel	10.270	3 870	.714	.131	.358	.224	1.380	.260	.174	.086	165.76	69.67	96.09	....
Beet pulp	3.216	.347	.185	.729	.283	.138	.048	.069	.006	.063	76.47	14.37	62.10	....
Clover hay	7.313	1.840	.067	1.236	.292	.190	.259	.183	.080	.103	135.49	30.98	104.51	....
Soy bean hay	8.580	1.774	.145	1.378	.692	.259	.084	.237	.121	.116	177.20	33.79	143.41	....
Cowpea hay	12.030	.873	.722	2.029	1.096	.352	.167	.283	.152	.131	244.85	44.89	199.96	....
Alfalfa hay	6.890	.832	.489	1.130	.400	.298	.161	.238	.122	.116	131.63	38.48	93.15	....
Timothy hay	3.470	.613	.345	.192	.111	.162	.199	.123	.052	.071	49.36	23.62	25.74	....
Millet hay	5 887	1.338	.099	.326	.262	.159	1.230	.173	.072	.101	76.21	24.56	51.65	....
Corn stover	7.007	1.847	.065	.507	.092	.187	.308	.102	.039	.063	82.83	26.93	55.90	....
Bluegrass	5.250	1.405	.141	.336	.240	.334	.234	.242	.142	.100	78.39	43.07	35.32	...
Wheat straw	3.650	.842	.237	.217	.063	.159	.209	.038	.015	.023	47.81	18.25	29.56	....
Agar agar	4.990	.132	.135	.780	.570	2.090	.040	.024	.003	.021	125 28	133.06	.....	7 78

TABLE III—MINERAL ELEMENTS OF LEGUMINOUS SEEDS, NITROGENOUS CONCENTRATES AND ANIMAL PRODUCTS
PARTS PER 100 OF DRY SUBSTANCE.

	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus	Inorganic phosphorus	Organic phosphorus	C. C. Normal Solution per 100 Grams			
											Total base	Total acid	Excess base	Excess acid
Soy beans	5.532	2.095	.380	.230	.244	.444	.025	.649	.017	.632	101.52	70.28	31.24	....
Navy beans	4.420	1.390	.086	.235	.206	.224	.047	.429	.088	.341	67.87	42.96	24.91	....
Cowpeas	4.302	1.636	.189	.117	.243	.280	.047	.532	.023	.509	75.67	53.08	22.59	....
Peanuts	2.538	.061	.563	.068	.180	.254	.024	.399	.049	.350	44.12	42.23	1.89	....
Linseed oil meal	6.463	1.224	.282	.403	.544	.455	.095	.786	.. .	....	109.07	81.78	27.29	....
Cottonseed meal	7.629	1.811	.283	.291	.599	.536	.042	1.479	.078	1.401	122.28	130.01	.....	7.73
Milk, skim	7.168	1.272	.488	1.336	.146	.357	.953	.979	.551	.428	132.26	112.35	19.91	....
Whey	9.278	2.762	.459	.721	.138	.139	1.948	.640	.402	.238	137.71	104.90	32.81	....
Mutton	2.386	.624	.214	.006	.062	.607	.235	.474	.230	.244	30.66	75.02	.....	44 36
Eggs	3.463	.206	.389	.250	.059	.762	.621	.856	trace	.856	39.42	120.28	.....	80.86
Tankage	17.050	.601	1.830	3.242	.159	.669	2.687	1.789	....	....	269.49	232.92	36.57	....
"Banner" bone flour.	100.000	.065	.091	23.990	1.160	....	....	14.940	14.940	....	. ...	.....	.....	....
Blood, swine.	4.740	1.040	1.370	.031	.028	.647	1.200	2.800	.076	.204	89.85	92.27	... .	2.42
"Black albumen"	4.640	.027	1.247	.039	.011	.820	1.550	.122	.037	.085	63.65	102.74	.....	39.09

TABLE IV—MINERAL ELEMENTS OF WHEATS VARIOUSLY FERTILIZED—PARTS PER 100 OF DRY SUBSTANCE

	Description	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus	Inorganic phosphorus	Organic phosphorus
1	Unfertilized	1.87	.523	.122	.051	.153	.243	.089	.403	.0229	.380
2	Phosphorus	1.82	.561	.127	.055	.149	.224	.073	.406	.0219	.384
3	Potassium	1.73	.497	.135	047	.152	.237	.112	.37	.0192	.351
4	Unfertilized	1.71	.442	.144	.049	.150	.256	.100	.357	.0181	.339
5	Nitrogen	1.73	.467	.147	.055	.154	.253	.096	.349	.0202	.329
6	Nitrogen; phosphorus	1.75	.467	.139	.057	.149	.243	.085	.358	.0186	.339
7	Unfertilized	1.80	.473	.113	.056	.152	.248	.102	.356	.0208	.335
8	Phosphorus; potassium	1.72	.443	.157	.044	.145	.213	.087	.372	.0179	.354
9	Nitrogen; potassium	1.61	.465	136	.043	.139	.258	.100	.337	.0185	.318
10	Unfertilized	1.67	.459	.128	.052	.144	.245	.091	.340	.0179	.322
11	Nitrogen; phosphorus; potassium	1 78	.449	.154	.046	.150	.228	.080	.395	.0207	.374
12	Nitrogen; phosphorus; potassium	1.77	.456	.128	.048	.149	.228	.079	.388	.0176	.370
13	Unfertilized	1.82	.451	.168	.053	.149	.241	.090	.359	.0170	.342

TABLE V—ORGANIC AND MINERAL ANALYSES OF FOODS—CEREAL PRODUCTS—PARTS PER 100 OF FRESH SUBSTANCE.

Description	Moisture	Protein (Nx6.25)	Nitrogen free extract	Ether extract	Crude fiber	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus
Wheat	12 31	10.31	69.59	1.54	2.82	1.64	.520	.031	.050	.130	.198	.084	.373
Wheat flour	13.92	9.74	74 67	1.25	.25	.165	.050	.110	.019	.016	.145	.070	.088
White bread	34.62	9.22	53.58	1.19	.28	1.11	.102	.381	.025	.003	.129	.626	.088
Wheat bran	10.02	15.75	55.30	4 26	8.62	6 06	1.320	.201	.125	.531	.267	.090	1.110
Wheat middlings	11.02	18.84	54.94	5.11	5.97	4.12	1.021	.165	.096	.383	.234	.025	.876
Wheat germ	8.50	29 44	44.37	10 07	2.91	4.71	.296	.721	.071	.340	.325	.070	1.050
Wheat gluten	8.42	80.88	9.15	.65	.19	.71	.007	.028	.078	.045	.920	.050	.200
Red dog flour	10.52	18.50	58 20	5.87	3.19	3.72	.380	.660	.120	.290	.260	.140	.830
Corn	14.24	8 69	69.11	4 03	2.72	1.21	.340	.026	.012	.108	.147	.063	.260
Corn meal, bolted	13.52	8.52	72.96	3.27	1.04	.69	.166	.098	.013	.106	.106	.061	.229
Corn bran	11.00	5 25	66.26	3.10	13.21	1.18	.365	.000	.027	.078	.110	.046	.139
Pearl hominy	11 90	6.88	78.77	1.46	.46	.53	.135	.000	.004	.032	.160	.046	.098
Gluten feed	7.99	27 50	48.86	3.64	8.83	3.18	.250	.424	.247	.220	.585	.090	.542
Distiller's grains, corn	7.71	32.06	37.52	8.90	12.43	1.38	.013	.142	.043	.050	.470	.060	.290
Distiller's grains, rye	8 33	29.25	36.93	6.76	15.34	3.39	.041	.071	.130	.179	.374	.026	.420
Brewer's grains	6.88	19.69	50.18	5 74	14.76	2.75	.172	.259	.157	.160	.390	.058	.468
Malt sprouts	7.46	24.75	45.53	2.10	14.46	5.70	.203	1.350	.147	.180	.800	.360	.690
Oats	8 89	10.88	60.09	4.28	12.48	3.38	.419	.168	.102	.118	.195	.070	.395
Kaffir corn	11.89	10.56	70.91	3.58	1.88	1.18	.254	.058	.012	.125	.164	.104	.239
Rice	10.15	6.48	82.26	.36	.47	.28	.036	.029	.008	.025	.102	.036	.093
Rice polish	11.13	12.48	54.29	11.77	3.20	7.13	1.137	.110	.027	.659	.168	.134	1.497

TABLE VI—ORGANIC AND MINERAL ANALYSES OF FOODS—FRUITS, VEGETABLES AND ROUGHAGE—PARTS PER 100 OF FRESH SUBSTANCE

Description	Moisture	Protein (Nx6.25)	Nitrogen free extract	Ether extract	Crude fiber	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus
Apple	85.25	.24	13.52	.10	.63	.27	.118	.010	.004	.005	.006	.005	.009
Prune, dried	24.53	2.78	66.67	1.26	1.61	2.15	1.017	.034	.057	.042	.050	.038	.083
Banana	72.63	1.13	24.79	.36	.29	.80	.353	.066	.010	.035	.006	.115	.033
Date, dried	15.44	2.26	77.44	.91	2.32	1.62	.564	.097	.071	.073	.074	.241	.065
Onion	87.29	1 64	9.41	.33	.79	.55	.183	.012	.033	.017	.076	.023	.041
Cabbage	93.05	1.16	4 80	.25	.31	.50	.173	.002	.041	.015	.063	.017	.018
Potato, sweet	73.34	1,28	23 35	.39	.80	.84	.322	016	.022	.057	.031	.018	.050
Potato, white	82.42	1.97	14.57	.09	.29	.67	.272	.031	.005	.058	.025	.010	.047
Mangel wurzel	88.54	1.68	7 69	.11	.80	1.18	.444	.082	015	.041	.026	.158	.030
Beet pulp, dried	9.53	8 25	59.29	.77	19.25	2.91	.314	.167	.660	.256	.125	.043	.062
Clover hay	7.57	13.00	40.74	3.06	28.87	6 76	1.701	.062	1.142	270	.176	.239	.169
Soy bean hay	10 61	17.09	36.57	2.47	25.59	7.67	1.586	130	1.232	.619	.231	.075	.212
Cowpea hay	10 62	22 25	33 64	3 03	19 70	10.76	.780	646	1.814	.980	.315	.149	.253
Alfalfa hay	7.42	14 41	40.44	1.87	29.48	6.38	.770	453	1.046	.370	.276	.149	.221
Timothy hay	8.06	5 34	48.13	2 29	32.98	3.20	.564	.317	177	.102	.149	.183	.113
Millet hay	4.89	6.00	47.56	2.89	33.06	5.60	1.273	.094	.310	.249	.151	.117	.165
Corn stover	6.96	5.48	46.88	1.39	32.77	6.52	1.718	.061	.472	.086	.174	.287	.095
Bluegrass hay	8.21	9.10	40.97	2.89	34.01	4.82	1 290	.129	.308	.220	.307	.215	.222
Wheat straw	5 48	1 75	45.13	1.71	42.48	3 45	.796	.224	.205	.060	.150	.198	.036
Agar agar, dried	15.29	1.88	77.34	.37	.89	4.23	.112	.114	.660	.483	1.770	.034	.020

NOTE—The high protein contents of soy bean hay and cowpea hay as above reported are due in part to the facts that these samples were a little less advanced in maturity than as usually cut for hay and were dried in the laboratory without loss of parts.

TABLE VII—ORGANIC AND MINERAL ANALYSES OF FOODS—LEGUMINOUS SEEDS, NITROGENOUS CONCENTRATES AND ANIMAL PRODUCTS
PARTS PER 100 OF FRESH SUBSTANCE.

Description	Moisture	Protein (Nx6.25)	Nitrogen free extract	Ether extract	Crude fiber	Ash	Potassium	Sodium	Calcium	Magnesium	Sulphur	Chlorine	Phosphorus
Soy beans	8.63	39.41	22.54	19.27	5.09	5.06	1.913	.343	.210	.223	.406	.024	.592
Navy beans	14.49	22.23	53.13	1.77	4.60	3 78	1.186	.074	.201	.176	.192	.040	.367
Cowpeas	14.24	22.14	52.94	1.33	5.66	3.69	1.403	.162	.100	.208	.240	.040	.456
Peanuts, roasted	2.71	27.41	17.32	47.95	2.14	2.47	.059	.548	.066	.175	.247	.023	.388
Linseed oilmeal	10.34	35.51	30.91	6.24	11.20	5.80	1.098	.253	.362	.488	.408	.085	.705
Cottonseed meal	8.58	35.88	30.27	11.14	7 15	6.98	1.656	.259	.266	.548	.490	.038	1.352
Milk, skim	90.41	3.21	5.52	.18	....	.69	.122	.047	.128	.014	.034	.091	.094
Whey	93.96	.79	4.69	.01	....	.56	.167	.028	.044	.008	.008	.118	.039
Mutton	61 67	17.18	....	20.26	....	.92	.239	.082	.002	.024	.233	.090	.182
Eggs	73.22	12.93	....	10.21	....	.93	.055	.104	.067	.016	.204	.166	.229
Tankage, digester	9.06	58.59	....	9.29	4.36	15.51	.547	1.664	2.948	.145	.608	2.444	1 627
"Banner" bone flour	....	.....	....	....	....	....	.065	.091	23.990	1.160	....	.....	14 940
Blood, swine	78 82	20.69	....	.27	....	1.00	.220	.290	.007	.006	.137	.250	.059
"Black albumen"	10.76	82.13	....	1.02	....	4.14	.240	1.247	.035	.010	.730	1.380	.109

NOTICE

The following publications of this Station have not been sent to the entire mailing list, because of the technical character of some of them and of the limited areas in which others are likely to be found interesting. Any of these publications, however, will be sent free to any address on application. Address, EXPERIMENT STATION, Wooster, Ohio.

BULLETINS PUBLISHED LESS THAN FULL EDITION

Bulletin 234—Flour Mill Fumigation, by W. H. Goodwin, January, 1912.

Bulletin 238—Tobacco Culture in Ohio, by A. D. Selby and True Houser, March, 1912.

Bulletin 239—Tobacco: Breeding Cigar Filler in Ohio, by A. D. Selby and True Houser, April, 1912.

Bulletin 244—Sweet Clover, by W. A. Lloyd, June, 1912.

Bulletin 247—Nitrogen and Mineral Constituents of the Alfalfa Plant, by J. W. Ames and Geo. E. Boltz, June, 1912.

Bulletin 255—Mineral and Organic Analyses of Foods, by E. B. Forbes, January, 1913.

Bulletin 256—The Miami County Experiment Farm; Second Annual Report for 1912, February, 1913.

Bulletin 258—The Paulding County Experiment Farm; Second Annual Report for 1912, February, 1913.

Circular 124—Horticultural Information, May, 1912.